sonal digital assistant, a tabletop computer, a personal computer, a laptop computer, a mini-tablet computer, a tablet computer, or the like.

[0085] Each of these devices may include at least one processor, respectively indicated as **414**, **424**, and **434**. At least one memory can be provided in each device, as indicated at **415**, **425**, and **435**, respectively. The memory may include computer program instructions or computer code contained therein. The processors **414**, **424**, and **434** and memories **415**, **425**, and **435**, or a subset thereof, can be configured to provide means corresponding to the various blocks of FIG. **3**. Although not shown, the devices may also include positioning hardware, such as global positioning system (GPS) or micro electrical mechanical system (MEMS) hardware, which can be used to determine a location of the device. Other sensors are also permitted and can be included to determine location, elevation, orientation, and so forth, such as barometers, compasses, and the like.

[0086] As shown in FIG. **4**, transceivers **416**, **426**, and **436** can be provided, and each device may also include at least one antenna, respectively illustrated as **417**, **427**, and **437**. The device may have many antennas, such as an array of antennas configured for multiple input multiple output (MIMO) communications, or multiple antennas for multiple radio access technologies. Other configurations of these devices, for example, may be provided. For example, network element **430** may be configured to communicate using wired communications, rather than having an antenna for communicating wirelessly and in such a case antenna **437** would illustrate any form of communication hardware, without requiring a conventional antenna. The communication can be, for example, via optical cables, or whatever transmission, such as microwave transmission or anything that is already deployed at operator side. Thus, the antenna **437** is merely illustrative of one example of the many forms of communication hardware that the network element **430** may have, if desired.

[0087] Transceivers **416**, **426**, and **436** can each, independently, be a transmitter, a receiver, or both a transmitter and a receiver, or a unit or device that is configured both for transmission and reception.

[0088] Processors **414**, **424**, and **434** can be embodied by any computational or data processing device, such as a central processing unit (CPU), application specific integrated circuit (ASIC), or comparable device. The processors can be implemented as a single controller, or a plurality of controllers or processors.

[0089] Memories **415**, **425**, and **435** can independently be any suitable storage device, such as a non-transitory computer-readable medium. A hard disk drive (HDD), random access memory (RAM), flash memory, or other suitable memory can be used. The memories can be combined on a single integrated circuit as the processor, or may be separate from the one or more processors. Furthermore, the computer program instructions stored in the memory and which may be processed by the processors can be any suitable form of computer program code, for example, a compiled or interpreted computer program written in any suitable programming language.

[0090] The memory and the computer program instructions can be configured, with the processor for the particular device, to cause a hardware apparatus such as UE **410**, eNB **420**, and network element **430**, to perform any of the processes described above (see, for example, FIG. **3**). Therefore, in certain embodiments, a non-transitory computer-readable medium can be encoded with computer instructions that, when executed in hardware, perform a process such as one of the processes described herein. Alternatively, certain embodiments of the invention can be performed entirely in hardware.

[0091] Furthermore, although FIG. **4** illustrates a system including a UE, eNB, and network element, embodiments of the invention may be applicable to other configurations, and configurations involving additional elements.

[0092] One having ordinary skill in the art will readily understand that the invention as discussed above may be practiced with steps in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, although the invention has been described based upon these preferred embodiments, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention. In order to determine the metes and bounds of the invention, therefore, reference should be made to the appended claims

[0093] Glossary

[0094] 1-D One Dimension

[0095] 2D Two Dimension

[0096] 3D Three Dimension

[0097] 3GPP Third Generation Partnership Project

[0098] ASIC Application Specific Integrated Circuit

[0099] CoMP JT Coordinated Multipoint Joint Transmission

[0100] CPU Central Processing Unit

[0101] CRS Cell-specific Reference Signal

[0102] CS Compressed Sensing/Compressive Sensing

[0103] CSI Channel State Information

[0104] CSI-RS Channel State Information Reference Signal

[0105] DoA Direction of Arrival

[0106] DCI Downlink Control Indicator

[0107] eNB Evolved Node B

[0108] EM Electromagnetic

[0109] FDD Frequency Division Duplex

[0110] FD-MIMO Full Dimension MIMO

[0111] HDD Hard Disk Drive

[0112] LTE Long Term Evolution of 3GPP

[0113] MIMO Multiple-Input Multiple-Output

[0114] mmWave Millimeter Wave

[0115] MU-MIMO Multi-User MIMO

[0116] PMI Precoding Matrix Index

[0117] PRB Physical Resource Block

[0118] PRSP Pseudo-Random Sampling Pattern

[0119] PUSCH Physical Uplink Shared Channel

[0120] RAM Random Access Memory

[0121] RE Resource Element

[0122] RF Radio Frequency

[0123] Rel Release

[0124] ROM Read Only Memory

[0125] Rx Receive/Reception

[0126] S-CSI-RS sparse CSI-RS

[0127] TDD Time Division Duplex

[0128] Tx Transmit/Transmission

[0129] UE User Equipment

We claim:

1. A method, comprising:

configuring, at a base station, a plurality of reference signals as sampling points for channel state information;